Maths Modelling Challenge: Years 7 - 12

Teacher Handout

Scenario: Social Media - Carbon Footprint

Posting a selfie on a social media platform, sending that selfie over a network and then storing the data on a server has an associated CO_2 emission of which many social media users remain unaware. In fact, streaming and data services are one of the largest producers of CO_2 emissions after transport and animal agriculture.

Climate change is a key issue of the 21st Century. Many governments, industry and the individual are taking responsibility to reduce the negative impacts that human-related activities are having on the environment. An environmental research team based at USC has asked your group to help raise awareness around the alarming hidden cost posting selfies has in its contribution to CO_2 emissions. The research team has asked you to help them calculate the environmental impact of posting selfies, as well as putting this into context to raise awareness of social media users carbon footprint associated with their daily social media actions.

There are many ways to approach this problem but a good place to start is to consider a selfie as data and then convert data MB into electricity efficiency CO_2/kWH.

(Students can use their own mobile phone WhatsApp data size. Alternatively, they can google data sizes for WhatsApp group chats. Student access to mobile phone is at discretion of school.)

Key points the research team have asked you to address are:

- How much of Australia's annual CO_2 emissions is generated from Australian WhatsApp users posting a single selfie per day on the social media platform?
- What area of trees are needed to absorb this amount of CO_2?
- How can you help? If you and your social network group posted 10% less data content to your group chat what would the reduction in CO_2 emission be over a year?
- Can you put this into context in terms of amount of natural CO_2 sinks (such as forest, coral reefs etc) freed up to absorb CO_2 emissions from other sources?

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USEFUL RESOURCES

There are many ways to approach this problem and many sources for reference. Below is a list of useful links and hints that provide some background reading and may aid in your approach to the problem. These can all be accessed without special licenses to journals.

The environmental cost of being selfish

https://www.core-econ.org/wp-content/uploads/2019/07/Data-competition-selfie.pdf

Moving data through a network

There are various sources that reference moving data through a network and little consistency in the analysis; some include hard-drive activity and storage, and others do not. It's difficult to tell where the number really lies!

Some sources provide values of between 3 to 7 kWh/GB for transporting and storing data in the cloud therefore, the Costenaro and Duer 2012 value of 5 kWh/GB was chosen. However, if you prefer to use other values here are some refs as well as Costenaro and Duer 2012.

https://www.semanticscholar.org/paper/The-Megawatts-behind-Your-Megabytes%3A-Going-from-to-Costenaro-Duer/e1128ae4c753b41a27b8a25a906cf3ac44d9cb5d (If link doesn't work cut and paste into browser)

Evaluating the Energy Consumption of Mobile Data Transfer—From Technology Development to Consumer Behaviour and Life Cycle Thinking Hanna Pihkola, Mikko Hongisto, Olli Apilo and Mika Lasanen Sustainability 2018, 10, 2494; doi:10.3390/su10072494

https://onlinelibrary.wiley.com/doi/pdf/10.1111/jiec.12630

https://medium.com/stanford-magazine/carbon-and-the-cloud-d6f481b79dfe

CO_2 absorption rate of trees

There are many references that can easily be found online. Ensure you reference the source for the value you choose. Below are some references to get you started.

https://www.thequint.com/tech-and-auto/how-many-trees-needed-to-absorb-co2-sadhguru-and-quint-calculations

http://www.truevaluemetrics.org/DBpdfs/Forests/Tree-Nation-Tropical-tree-sequestration-of-CO2.pdf

https://savingnature.com/offset-your-carbon-footprint-carbon-calculator/?gclid=Cj0KCQjwn-v71BRCOARIsAIkxW9Ed-ldr_jHXFwiiody30cSgO-3laCfgb51byB0jD5QTPHqBFh0CPW9AaAiSuEALw_wcB

Helpful Hint - Conversion of a selfie into CO_2 emissions

The average electricity efficiency for sending and storing data in Australia can be modelled in gCO_2/kWh. Then convert data into kWh using a conversion rate from the above literature with units kWh/GB

For example:
1 selfie = 2MB = 0.002GB
1 selfie when uploaded to WhatsApp gets down sampled to ~100KB = 0.0001GB
in terms of electricity 1 selfie = 0.0001GB x conversion rate kWh/GB = XX kWh
CO_2 emission of 1 selfie = gCO_2/kWh x kWh = XX gCO_2

Helpful Hint - Finding your own data consumption

You can view the data usage of a single message/photo or entire chat group by looking at the settings of the social media account on your phone. As an example to view data used in WhatsApp navigate to Settings/Data and Storage Usage/Network Usage or Storage Usage.

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~: symbol for approximately

Average electricity efficiency: Is the how efficient a network is at sending data and is quoted in grams of CO_2 per kilowatt hour (gCO_2/kWh) and defines the amount of CO_2 emitted per unit of electricity. Lower values are more environmentally friendly.

CO_2: carbon dioxide

Carbon absorption rate of trees: A process whereby carbon is removed from the atmosphere and stored long-term in trees, roots and soil.

Cloud: using a network hosted on the internet to store, manage and process data rather than a personal computer.

Greenhouse gas emission: The release of harmful gases into our environment from transport, industry and other human activity.

GB: gigabyte is a measurement of data storage for computers, tablets, smartphones, and other computing devices. 1 GB = 1000MB or 230 bytes.

gCO_2/kWh: grams of carbon dioxide per kilowatt hour

kWh: Kilowatt hour is a measure of electrical energy equivalent to a power consumption of one thousand watts for one hour.

KB: kilobytes is a measurement or unit of memory or data storage for computers, tablets, smartphones, and other computing devices that is equal to 1024 (210) bytes. Due to convenience and because 1024 is approximately 1000 the prefix kilo is used.

MB: megabyte is a measurement of data storage for computers, tablets, smartphones, and other computing devices. 1MB = 1000KB or 220 bytes.

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Additional Notes for Teachers

All entries must be students' own work and verified on submission. Acceptable teacher support for students please refer to below *Footnotes - points of discussion and exploration.*

- Students will need to research the number of WhatsApp users in Australia, the CO_2 cost of posting one selfie on an Australian network and the CO_2 absorption rate of carbon sinks such as mangroves and subtropical rainforests.
- There are many sources and studies quoting different values to convert data into kWh. This value can change depending on the data transfer and storage efficiency being considered anddepending on where you look can range from 3-7kWh/GB. To make it easier for the students we have provided a work through below to convert a selfie into CO_2 emissions using the value of 5kWh/GB from Costenaro and Duer 2012 paper. You may want to work through this example to demonstrate how to convert data into amount of CO_2 emissions with your students. However, the below is just an example and there are many different ways to tackle the problem.
- Encourage the students to think of selfies in terms of data – a standard photo is ~2MB and then think about the electricity (kWh/MB) required to send and store this data across networks and servers.
- When modelling the potential to reduce the carbon footprint of their own social network they will need to think about number of friends within their network and how many selfies they each post a month.

Example Work Through

Conversion of a selfie into CO_2 emissions *

The average electricity efficiency for sending and storing data in Australia can be modelled as 1000gCO_2/kWh**. To convert data into kWH use the average global value of 5kWh/GB (Costenaro and Duer 2012)

1 selfie = 2MB = 0.002GB
1 selfie when uploaded to WhatsApp gets down sampled to ~100KB = 0.0001GB
in terms of electricity 1 selfie = 0.0001GB x 5kWh/GB = 0.0005kWh
CO_2 emission of 1 selfie = 1000gCO_2/kWh x 0.0005 kWh = 0.5gCO_2

Annual CO_2 emissions of social media

Number of WhatsApp users in Australia = 6,000,000***
Average size of a single selfie uploaded to WhatsApp= 0.0001GB
Number of selfies a year = **N** =365 x 6,000,000

Total CO_2 emission = **N** x 0.5gCO_2 = 1.095 x e9gCO_2 = 1095 tons CO_2
1km2 of trees can absorb between 100 - 1,000 tons of CO_2 per year. Assume an average of 500 tons you would need **2.19km2 of trees** (range 1 - 11km2).****

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The CO_2 cost of a social network

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Data GB x 5kWh/GB x 1000gCO_2/kWh

Use the above equation to convert data GB of a single group chat into kWh and then to gCO_2. Students can pick one of their group chats to work off. Group history information can then be used to evaluate average data transfer per year which can then be used to calculate the CO_2 reduction if they were to send 10% less data‡. Students should then discuss how to implement this in practice (sending 1 less message a day etc), as well as discuss how are we going to deal with the existing CO_2 emissions of social networking. Put this in context of CO_2 absorption rates of several carbon sinks (which can be easily found on the internet, i.e. a tree can absorb 59 gCO_2 per day†).

Footnotes - Points of Discussion and Exploration

* You may wish to run through this example of converting 1 selfie to gCO_2 with the group at the start of the session.

** This may change depending on the country and infrastructure. The students might want to discuss the environmental impact of uploading photos whilst on vacation compared at home.

*** This can be found on Google.

**** This varies depending on age and species of tree as well as climate. A temperate deciduous forest may store less CO_2 annual than a rainforest for example. Students may wish to model different forest types that are typically found in Australia or another carbon sink entirely. These absorption rates can be found online.

‡ This will vary greatly from group to group, but students should justify their working out and evaluation.

† Students may want to consider and discuss several different initiatives to increase the number of carbon sinks to deal with the ever-increasing amount of data we are producing.

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